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A Bibliography on Underwater Telemetry, 1956-1990

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1991

Canadian Technical Report of Fisheries and Aquatic Sciences 1819

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92-00192/

Canadian Technical Report of
Fisheries and Aquatic Sciences 1819

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A BIBLIOGRAPHY ON UNDERWATER TELEMETRY, 1956-1990

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Cat No. Fs 97-6/1819E ISSN 0706-6457
DFO/4641

Published by and available from:

Department of Fisheries and Oceans
Communications Directorate
200 Kent Street
Ottawa, Ontario
K1A 0E6

Printed on recycled paper.

Correct citation for this publication:

Baras, E. 1991. A bibliography on underwater telemetry, 1956-1990. Can. Tech. Rep. Fish. Aquat. Sci. 1819: 55 p.

Table of Contents

Abstract/Résumé iv

Introduction 1

Bibliography

1. Review Papers 3

2. Books 4

3. Primary Publications 24

4. Reports and Conferences 42

Index

Species 46

Equipment and Techniques 52

Transmitter Attachment 54

Data Collection and Analyses 55

ABSTRACT

Baras, E. 1991. A bibliography on underwater telemetry, 1956-1990. Can. Tech. Rep. Fish. Aquat. Sci. 1819: 55 p.

The bibliography consists of over 1,100 references dealing with techniques and applications of telemetry to aquatic vertebrates (fishes, amphibia, reptiles, and mammals) and invertebrates. Citations date from 1956 to 1990 and refer to more than 160 animal species, listed in this paper. A general species and thematic index is also included.

RÉSUMÉ

Baras, E. 1991. A bibliography on underwater telemetry, 1956-1990. Can. Tech. Rep. Fish. Aquat. Sci. 1819: 55 p.

Cette bibliographie comporte plus de 1 100 références de publications relatives aux techniques et applications de la télémétrie aux vertébrés (poissons, batraciens, reptiles et mammifères) et invertébrés aquatiques. Ces références, datant de 1956 à 1990, ont trait à plus de 160 espèces animales, listées dans cette publication. Un index des espèces et thèmes abordés dans les publications est inclus dans le manuscrit.

Introduction.

The literature on underwater telemetry has been growing at an exponential rate with studies published in a wide range of journals, books, symposia and biological or technical reports so that it becomes harder for the biologist starting a new research project to find the right references. In 1972, Malinin and Svirskii reviewed 35 papers on underwater telemetry and Stasko presented 147 underwater telemetry publications in an annotated bibliography released in 1975. This report (bibliography completed in July, 1990) presents more than 1,100 references of publications dealing with telemetry techniques, applications and strategies of analyzing data. It should be noted that less that 40 % of these references appear in the Zoological Records or Aquatic Science and Fisheries Abstracts.

Since the first study of Trefethen (1956), underwater telemetry (optical, ultrasonic or radio) helped considerably in the study of the ecology, ethology or physiology of 168 species, including 102 fishes and sharks, , 2 amphibians, 12 reptiles, 33 mammals and 19 invertebrates. These species are listed in alphabetical order for each of these classes or phyla.

The bibliography was achieved from a collection of 900 papers belonging to the author and obtained from more than 100 researchers working in the field of telemetry. A manual search was also made from various data bases, review papers and books, in order to obtain the correct reference when the original publication was not available.

This bibliography is divided in five sections. The two first sections list review papers and books directly or indirectly related to telemetry. Primary publications on techniques and biological applications are presented in section 3. The 4th section groups biological and technical reports and communications presented in conferences and symposia. Theses and DEA reports, detailing all the aspects involved in a research work using telemetry, are listed in section 5. One could notice that some of the papers presented refer to wildlife telemetry : these papers present techniques or strategies of analysing tracking data and are included as complementary informations, since most of these informations (evaluation of home range, use of habitat,...) can be directly applied to underwater telemetry data and are not always detailed in the underwater telemetry litterature.

References are listed in alphabetical order in each of the five sections and works from the same author(s) are arranged chronologically. Readers may assume that a paper is written in the same language as that of the title, unless a note in parentheses indicates otherwise. When an English translation of the paper has been achieved, its reference is added to the reference of the original publication.

A general species and thematic index is presented at the end of the paper and should help the reader to find more easily his own centers of interest.

No bibliography is or should be considered as exhaustive and this compilation is no exception to the rule. The author apologizes in advance for the omissions or errors in citations and would appreciate to be informed of these.

I would like to thank all the authors sending the papers taking place in this bibliography and specially Dr. J.D. Winter and V.B. Kuechle as well as Prof. J.P. Gosse and his collaborators, who helped considerably in collecting the publications. Special thanks to O. Baras, who corrected the typing without loosing his patience and sense of humour.

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INDEX

The bibliographic entries are arranged alphabetically by author in each of the five sections, each entry numbered sequentially and without sequence rupture from a section to another. Books and general review papers from sections 1 and 2 are not taken into account in the index, except if their scope is almost exclusively related to one of the points defined below.

The index is divided into five main parts : Species : for application type articles only, scientific and common names are listed.
Equipment : for both instrumentation and application type articles in which biotelemetry instrumentation is discussed.
Parameters : for both instrumentation and application type articles in which telemetric measurements of parameters other than location or simple activity (e.g. : mercury tilt) are made.
Transmitter attachment : for articles presenting feasibility studies or attachment techniques.
Data collection and analyses : for articles presenting advances in data collection or processing.

SPECIES

The species are grouped in classes or phyla and listed in alphabetical order. Only species studied in application types articles are listed, except for the species only appearing in review papers. The most extensively studied group has been the salmonid fishes, with 10 species belonging to the genus *Oncorhynchus* and *Salmo* accounting for 248 studies, with a special emphasis on rainbow trout, chinook and Atlantic salmon. Other species with high economical importance, such as largemouth bass, eel, pike and walleye, have also been extensively studied.

Elasmobranchs (sharks)

shark sp. : 204, 403, 404, 405, 406, 637, 881, 882, 981.

Carcharhinus leucas (bull shark) : 556, 991.

Carcharhinus milberti (sandbar shark) : 96.

Carcharhinus obscurus (dusky shark) : 112, 239.

Carcharodon carcharias (white shark) : 118.

Cetorhinus maximus (whale shark) : 24, 28.

Gynglimostoma cirratum (nurse shark) : 2.

Heterodontus portusjacksoni (Port Jackson shark) : 110.

Lamna nasus (mackerell shark) : 115.

Mustelus canis (smooth dogfish) : 787.

Negaprion brevirostris (lemon shark) : cited in *Underw. Telem. Newsl.*, 11(2).

Prionace glauca (blue shark) : 113, 487, 961, 963, 1095.

Scyliorhinus canicula (dogfish) : 195.

Sphyrna lewini (hammerhead shark) : cited in *Underw. Telem. Newsl.*, 11(2).

Sphyrna zygaena (hammerhead shark) : 96.

Squatina californica (angel shark) : 515, 963, 1097.

Triaenodon obesus (reef whitetip) : 883.

Fishes

Abramis brama (bream) : 312, 313, 346, 347, 348, 425, 434, 437, 798, 799, 800, 801.

Acipenser brevirostrum (shortnose sturgeon) : 106, 367.

Acipenser fulvescens (lake sturgeon) : 684, 690, 739, 808, 809, 810.

Acipenser guldenstädti (Volga sturgeon) : 185, 353, 435, 440.

Acipenser transmontanus (white sturgeon) : 223, 225, 673, 1068.

Alosa alosa (Allis shad) : 526.

Alosa sapidissima (American shad) : 146, 147, 148, 289, 318, 319, 320, 321, 628, 692, 693, 754, 757, 812, 813, 814, 884, 1072.

Ambloplites rupestris (rock bass) : 187, 340, 660.

Anguilla anguilla (European eel) : 175, 303, 308, 542, 543, 544, 545, 546, 547, 548, 549, 598, 600, 982, 983, 984, 985, 1014, 1019, 1021.

Anguilla rostrata (American eel) : 228, 521, 522, 797.

Aristichthys nobilis (bighead) : 300.

Barbus barbus (barbel) : 91, 92, 426, 638, 639, 775, 893, 894, 1045.

Carassius auratus (goldfish) : 288, 788.

Catostomus commersonni (white sucker) : 22, 282, 472, 684, 795, 808, 809, 810, 1036.

Coregonus autumnalis (Arctic cisco) : 855.

Coregonus clupeaformis (lake whitefish) : 636, 647.

Coregonus nasus (broad whitefish) : 661.

Coryphyaenoides yaquinae (abyssal grenadier) : 449.

Ctenopharyngodon idella (grass carp) : 389, 411, 482.

Cyprinus carpio (carp) : 202, 267, 268, 305, 527, 564, 630, 643, 644, 731, 888, 1011, 1012.

Dissostichus mawsoni (Antarctic cod) : 552.

Dorosoma cepedianum (Gizzard shad) : 22.

Esox lucius (pike) : 84, 143, 144, 185, 230, 346, 347, 348, 355, 438, 472, 474, 564, 630, 636, 642, 647, 689, 690, 724, 731, 798, 799, 800, 808, 809, 810, 833, 929, 1033, 1111, 1112.

Esox masquinongy (muskellunge) : 22, 140, 381, 382, 384, 472, 695, 808, 809, 810, 1076.

Gadus morhua (cod) : 85, 142, 205, 216, 217, 278, 427, 586, 737, 744.

Gadus pollachius (coal fish) : 743.

Hiodon alosoides (goldeye) : 636, 647.

Hiodon tergisus (mooneye) : 809, 810.

Hypophthalmichthys molitrix (white amur) : 300, 401, 777, 778, 779, 780, 935.

Ictalurus nebulosus (brown bullhead) : 22, 280.

Ictalurus punctatus (channel catfish) : 356, 533, 617, 727, 728, 808, 809, 810, 1090.

Istiophorus platypterus (Atlantic sailfish) : 271.

Katsuwonus pelamis (skipjack tuna) : 93, 126, 278, 324, 616.

Lepomis gibbosus (pumpkinseed) : 168, 479, 932, 1057.

Lepomis macrochirus (bluegill) : 100, 168, 177, 453, 479, 932, 1057.

Leuciscus cephalus (chub) : 798, 799.

Lota lota (burbot) : 346, 349, 439, 622, 973, 978.

Makaira nigricans (Pacific blue marlin) : 1038.

Micropterus dolomieui (smallmouth bass) : 22, 187, 237, 238, 340, 395, 428, 560, 641, 660, 809, 810, 1064, 1070, 1080.

Micropterus salmoides (largemouth bass) : 100, 141, 149, 168, 323, 373, 380, 385, 410, 454, 455, 463, 464, 474, 478, 479, 561, 585, 605, 641, 669, 680, 681, 682, 683, 690, 694, 732, 808, 809, 810, 827, 892, 911, 929, 932, 1044, 1049, 1050, 1051, 1057, 1078, 1080, 1089, 1090, 1096, 1109, 1113.

Micropterus treculi (Guadalupe bass) : 836, 1070.

Morone americana (white perch) : 375, 1075.

Morone chrysops (white bass) : 22, 212, 229, 520, 862.

Morone punctatus (spotted bass) : 892, 1080.

Morone saxatilis (striped bass) : 139, 151, 153, 165, 302, 397, 671, 677, 678, 884, 934, 975, 977, 1002, 1094, 1099, 1103.

Morone saxatilis x M. chrysops (sunshine bass) : 611.

Oncorhynchus gorbuscha (pink salmon) : 523.

Oncorhynchus keta (chum salmon) : 761, 927.

Oncorhynchus kisutch (coho salmon) : 220, 266, 270, 279, 481, 596, 656, 698, 834, 878, 940, 1087, 1107.

Oncorhynchus nerka (Sockeye salmon) : 32, 78, 198, 199, 200, 326, 343, 344, 413, 456, 524, 627, 698, 729, 927.

Oncorhynchus tshawytscha (chinook salmon) : 98, 107, 108, 137, 191, 192, 220, 222, 266, 270, 279, 562, 596, 653, 655, 667, 684, 688, 690, 733, 741, 771, 772, 773, 816, 817, 818, 819, 820, 821, 822, 823, 860, 868, 869, 870, 871, 872, 873, 874, 875, 1027, 1068, 1107.

Perca flavescens (yellow perch) : 168, 282, 390, 473, 474, 475, 479, 660, 833, 853, 929, 932, 1057, 1091.

Pleuronectes platessa (plaice) : 85, 194, 196, 206, 278, 387.

Polyodon spatula (paddlefish) : 510, 706.

Pomoxis annularis (white crappie) : 931, 1092.

Pomoxis nigromaculatus (black crappie) : 931, 1092.

Ptychocheilus lucius (Colorado squawfish) : 44, 569, 570, 572, 573, 574, 575, 633, 749, 913, 946, 995, 1025.

Pylodictis olivaris (flathead catfish) : 208, 209, 472, 727, 728, 974, 976, 1067.

Rutilus rutilus (roach) : 798, 799.

Salmo clarki (cutthroat trout) : 89, 362, 364, 488, 553, 825, 945.

Salmo gairdneri (rainbow trout) : 98, 130, 137, 169, 224, 241, 270, 272, 273, 283, 289, 325, 330, 375, 391, 393, 412, 413, 468, 469, (renamed *Oncorhynchus mykiss*) 593, 595, 597, 618, 619, 622, 645, 654, 657, 684, 703, 808, 809, 810, 819, 820, 821, 825, 828, 829, 871, 872, 874, 876, 889, 923, 924, 958, 959, 969, 970, 973, 978, 979, 1003, 1027, 1036, 1039, 1063, 1074, 1075, 1083, 1088, 1106, 1109, 1112.

Salmo salar (Atlantic salmon) : 83, 88, 94, 102, 105, 128, 152, 158, 164, 170, 171, 186, 218, 227, 278, 289, 309, 350, 351, 352, 361, 363, 366, 407, 434, 435, 436, 442, 443, 451, 500, 501, 518, 528, 555, 568, 615, 631, 730, 736, 738, 743, 747, 750, 751, 784, 802, 806, 904, 905, 909, 928, 948, 949, 950, 951, 971, 987, 990, 997, 1017, 1018, 1020, 1055, 1060, 1102, 1108.

Salmo trutta fario (brown trout) : 174, 219, 221, 233, 266, 408, 423, 448, 471, 486, 511, 554, 567, 597, 690, 716, 717, 718, 719, 720, 722, 723, 808, 809, 810, 908, 1015, 1016, 1047, 1077.

Salmo trutta trutta (sea trout) : 500, 802, 951.

Salvelinus alpinus (brook trout) : 365, 1036.

Salvelinus fontinalis x *S. Namaycush* (splake) : 645.

Salvelinus namaycush (lake trout) : cited in 40 (Stasko, unpublished data).

Scaphirhynchus platorhynchus (shovelnose sturgeon) : 240.

Sciaenops oscellata (red drum) : 125.

Scomber japonicus (Pacific mackerel) : 278.

Seriola quinqueradiata (yellowtail) : 150, 244, 274, 334, 383, 576.

Solea solea (sole) : 195, 310.

Stenodus leucichthys (inconnu or sheefish) : 624, 855.

Stizostedion vitreum canadense (sauger) : 1031, 1032.

Stizostedion lucioperca (pikeperch) : 346.

Stizostedion vitreum vireum (walleye) : 22, 74, 176, 234, 281, 368, 472, 474, 535, 636, 647, 684, 690, 699, 808, 809, 810, 863, 864, 865, 877, 929, 1041, 1054, 1061, 1082, 1100, 1114.

Tautoga onitis (tautog) : 419, 420.

Tautogolabrus adspersus (cunner) : 419.

Tetrapterus albidus (white marlin) : cited in 40 (F.C. Carey and D.G. Pincock, unpublished data).

Thunnus alajunga (albacore) : 126, 314, 803.

Thunnus obesus (bigeye tuna) : 112.

Thunnus thynnus (bluefin tuna) : 96, 112, 113, 114, 116, 117, 118, 901.

Thymallus arcticus (Arctic grayling) : 622.

Xiphias gladius (swordfish) : 111, 113.

Xyrauchen texanus (razorback sucker) : 571, 572, 575, 995.

Mammals

Balaena mysticetus (bowhead whale) : 284, 665, 666, 708, 710, 742, 785, 918, 956, 957.

Balaenoptera edeni (Bryde whale) : 588, 1007.

Balaenoptera musculus (blue whale) : 917.

Balaenoptera physalus (fin whale) : 316, 459, 588, 591, 592, 917, 1004, 1008, 1009.

Callorhinus ursinus (fur seal) : 77, 87, 345, 613, 635, 830.

Delphinapterus leucas (Belukha whale) : 172, 712, 918.

Delphinus delphis (Atlantic common dolphin) : 160, 316, 1056.

Dugong dugon (dugong) : 839, 914, 915.

Enhydra lutris (sea otter) : 181, 182, 183, 329, 465, 494, 551, 604, 1062, 1080.

Eschrichtius robustus (gray whale) : 162, 210, 316, 358, 414, 415, 537, 844, 846.

Eubalaena glacialis (right whale) : 937.

Globicephala scammoni (pilot whale) : 161, 316, 651.

Homo sapiens (humans) : 277, 495, 525.

Hydrurga leptonyx (leopard seal) : 550.

Lagenorhynchus obscurus (dusky porpoise) : 316, 1034, 1035.

Lagenorhynchus obliquidens (Pacific whiteside) : 316.

Leptonychotes weddelli (weddel seal) : 2, 489, 491, 492, 493, 552.

Lobodon carcinophagus (crabeater seal) : 550.

Lutra canadensis (nearctic river otter) : 27, 236, 377, 378, 461, 609, 626, 701, 856, 857, 858, 903, 1058, 1085, 1110.

Lutra lutra (palearctic river otter) : 386.

Megaptera novaeangliae (humpback whale) : 316, 357, 588, 589, 591, 726, 837, 838, 992, 993, 1008.

Orcinus orca (killer whale) : 161, 316, 485, 651, 700.

Phoca vitulina (harbor seal) : 433.

Phocoena phocoena (harbor porpoise) : 2, 95, 184, 460, 919.

Phocoenoides dalli (Dall's porpoise) : 316.

Physeter macrocephalus (sperm whale) : 735.

Stenella attenuata (spotted dolphin) : 109, 315, 316, 807, 943.

Stenella longirostris (spinner porpoise) : 316, 590.

Steno bradanensis (rough toothed dolphin) : 2.

Trichechus ininguis (Amazonia manatee) : 99, 394.

Trichechus manatus (Florida manatee) : 251, 357, 839, 859, 887, 1030, 1042.

Tursiops gilli (bottlenose dolphin) : 2.

Tursiops truncatus (bottlenose dolphin) : 13, 252, 315, 336, 337, 339, 462, 538, 539, 566, 765, 766, 980.

Reptiles

Alligator mississipiensis (American alligator) : 190, 263, 264, 311, 371, 467, 497, 498, 499, 512, 962.

Amblyrhynchus cristatus (marine iguana) : 338.

Caretta olivacea (loggerhead turtle) : 284, 399, 508, 529, 558, 559, 687, 762, 776, 954, 955, 968.

Chelodina longicollis (freshwater turtle) : 531.

Chelonia mydas (green turtle) : 80, 90, 121, 122, 123, 124, 145, 245, 246, 250, 370, 508, 516, 879.

Chelydra serpentina (common snapping turtle) : 398, 418.

Crocodylus johnstoni (Australian freshwater crocodyle) : 79, 197, 269.

Crocodylus porosus (marine crocodile) : 79, 197, 269, 612.

Dermochelys coriacea (leatherback turtle) : 155, 156, 157, 284, 517, 1053.

Lepidochelys kempi (Kemp's ridley turtle) : 559, 912.

Mauremys japonica (Japanese freshwater turtle) : 254.

Pseudemys scripta (slider turtle) : 390, 484, 513, 942, 1098.

Amphibia 579

Buergeria buergeri (Rhacophoridae) : 173, 532.

Rana catesbeiana (bullfrog) : 22, 679.

Invertebrates

Callinectes sapidus (blue crab) : 232, 608, 1029.

Cancer pagurus (European edible crab) : 781.

Chionoecetes opilio (snow crab) : 848.

Homarus americanus (American lobster) : 332, 849.

Homarus vulgaris (European lobster) : 743.

Illex illecebrosus (squid) : 594, 1105.

Jasus novaehollandiae (rock lobster) : 81, 458.

Limulus polyphemus (horseshoe crab) : 249, 764.

Macrobrachium rosenbergi (macrobrachium) : 1079.

Nautilus belauensis (nautilus) : 119, 120, 584, 960.

Nephrops norvegicus (Norway lobster) : 662, 663, 672.

Nerita textilis (Nerita) : 129.

Panulirus argus (spiny lobster) : 132, 231.

Panulirus cygnus (rock lobster) : 262, 429.

Paralithodes camtschatica (king crab) : 392.

Strombus gigas (queen conch) : 132.

Triodopsis albolabis major (Triodopsis) : 577.

Unionidae (American freshwater mussels) : 409.

Zooplankton (mimic) : 1028.

EQUIPMENT AND TECHNIQUES

Listed below are the papers dealing with technical descriptions of transmitting or receiving equipment (transmitter, antennae, hydrophones and receivers). Publications principally concerned with wave propagation problems (absorption, range, frequencies) and position accuracy (errors, reflections, precision) are listed in separate rubriques.

Transmitters : 50, 51, 84, 90, 96, 97, 101, 131, 134, 163, 167, 169, 174, 185, 186, 196, 203, 206, 229, 244, 247, 255, 278, 292, 293, 301, 306, 307, 316, 328, 332, 333, 336, 345, 372, 387, 388, 392, 396, 406, 417, 430, 447, 462, 480, 483, 496, 497, 525, 534, 551, 563, 582, 587, 601, 610, 614, 615, 617, 620, 636, 646, 648, 652, 659, 662, 670, 676, 702, 705, 713, 715, 721, 734, 745, 746, 747, 748, 762, 763, 767, 770, 771, 772, 774, 783, 790, 822, 825, 826, 832, 841, 842, 843, 847, 850, 857, 858, 866, 867, 880, 882, 890, 895, 896, 897, 898, 899, 901, 902, 906, 908, 909, 916, 920, 921, 922, 930, 937, 953, 961, 962, 963, 988, 989, 991, 994, 999, 1000, 1005, 1006, 1027, 1029, 1037, 1043, 1046, 1048, 1063, 1071, 1088, 1097.

Receivers : 50, 51, 90, 96, 97, 134, 163, 174, 206, 248, 278, 306, 316, 406, 495, 563, 614, 620, 636, 646, 648, 670, 702, 715, 721, 745, 746, 747, 748, 753, 762, 763, 770, 771, 772, 786, 792, 793, 825, 832, 843, 847, 857, 858, 890, 895, 896, 897, 898, 899, 900, 901, 906, 908, 930, 937, 952, 988, 991, 994, 999, 1001, 1027, 1037, 1043, 1052, 1065, 1088, 1097.

Antennae : 45, 50, 51, 76, 97, 134, 215, 306, 503, 602, 636, 640, 646, 668, 698, 715, 721, 753, 762, 770, 771, 796, 811, 832, 843, 857, 890, 937, 944, 1027, 1043.

Hydrophones : 50, 96, 178, 206, 217, 248, 406, 519, 542, 563, 565, 582, 590, 614, 620, 670, 745, 746, 747, 748, 772, 815, 899, 964, 965, 966, 989, 991, 994, 999, 1065.

Propagation : 52, 53, 71, 73, 103, 257, 374, 376, 430, 431, 503, 540, 652, 753, 811, 910, 944, 964, 966, 996, 998, 1043, 1101.

Accuracy and errors in detection : 180, 226, 317, 424, 476, 514, 602, 603, 756, 986, 1024, 1052, 1065, 1066.

PARAMETERS

Listed below are the articles focussing on telemetric parameters other than location-only or simple-activity. Some articles present multichannel systems. Most studies deal with temperature or pressure telemetry but many other parameters have been monitored, the most recent being presented in the "molt detection" and "oxygene-sensing" systems.

Temperature : 2, 100, 111, 112, 113, 115, 116, 117, 118, 138, 139, 145, 162, 167, 241, 244, 266, 269, 273, 294, 296, 298, 299, 307, 311, 336, 337, 338, 339, 360, 370, 403, 406, 422, 439, 462, 463, 464, 473, 483, 484, 487, 497, 498, 511, 512, 513, 515, 516, 517, 525, 676, 678, 695, 705, 751, 770, 804, 832, 853, 880, 881, 901, 902, 906, 907, 908, 921, 922, 925, 929, 930, 934, 961, 962, 963, 1002, 1028, 1038, 1044, 1051, 1071, 1089, 1091, 1094, 1095, 1097, 1098, 1103, 1113.

Pressure : 2, 111, 118, 119, 120, 160, 162, 167, 178, 191, 196, 243, 266, 277, 278, 331, 403, 487, 515, 521, 544, 545, 546, 548, 549, 584, 620, 651, 705, 735, 743, 745, 747, 748, 750, 751, 770, 872, 881, 896, 901, 902, 926, 930, 961, 962, 963, 984, 985, 1018, 1020, 1021, 1028, 1097, 1105, 1108.

Respiration rate : 110, 159, 277, 370, 412, 463, 525, 536, 595, 840, 1036, 1106.

EMG : 204, 423, 468, 469, 471, 593, 594, 608, 664, 670, 831, 890, 923, 924, 1010, 1029, 1088.

ECG and heart rate: 2, 101, 169, 277, 278, 412, 413, 444, 448, 463, 496, 497, 499, 525, 530, 536, 586, 595, 607, 637, 825, 832, 1036, 1106.

Swimming speed : 90, 167, 204, 403, 406, 487, 515, 580, 705, 881, 961, 962, 963, 1097.

Compass direction : 90, 167, 205, 388, 406, 705, 881, 961, 962, 963, 1028, 1097.

Illumination : 167, 185, 186, 403, 406, 487, 515, 705, 961, 962, 963, 1028, 1097.

Tail beat : 520, 686, 748, 1021.

Posture : 881.

Olfactory stimulation : 2, 305, 637.

EEG : 787.

Salinity : 354, 445, 880, 901, 902, 909.

Oxygene sensing : 450, 451

PH : 789.

CO2 partial pressure : 525.

Molt detector : 1029.

TRANSMITTER ATTACHMENT

The relative success of telemetric studies relies on two basic assumptions : 1) the animal should survive handling and tagging procedures and keep its transmitter as long as possible ; 2) the behaviours of tagged and untagged animals should not be significantly different. Unfortunately, there is no universal attachment method : general or specific problems directly linked to unappropriate attachment procedures have been met in numerous telemetric studies (see Table I for fish species).

Table I. (G = Gut insertion ; E = External attachment ; S = Surgical implantation)

Problem faced	Species	Attachment	Reference
Reduction of survival	*Esox masquinongy* (muskellunge)	S	695
	Perca flavescens (yellow perch)	E	475
	Pylodictis olivaris (flathead catfish)	S	472
	Hypophthalmichthys molitrix (white amur)	S	401
	Micropterus treculi (Guadalupe bass)	S	1073
Induction of negative buoyancy	*Lepomis macrochirus* (bluegill)	G	177
	Salmo salar (Atlantic salmon)	E	171
Regurgitation	*Oncorhynchus* spp. (Pacific salmons)	G	774
	Salmo gairdneiri (rainbow trout)	G	774
	Salmo trutta trutta (sea trout)	G	951
	Anguilla rostrata (American eel)	G	521
	Seriola quinqueradiata (yellowtail)	G	244
Rupture of oesophagus	*Salmo salar* (Atlantic salmon)	G	951
	Salmo clarki (cutthroat trout)	G	364
Gut atrophy	*Oncorhynchus tshawytscha* (chinook salmon)	G	1068
Post-release hyperactivity	*Gadus morhua* (cod)	G	216
Reduction of swimming speed	*Salmo salar* (Atlantic salmon)	G, E	363
Increased downstream movement	*Oncorhynchus tshawytscha* (chinook salmon)	G	741
Loss of transmitter	*Salmo trutta trutta* (sea trout)	E	802
Transmitter entangled in vegetation	*Perca flavescens* (yellow perch)	E	475
Transmitter torn by rocky substrate	Salmo salar (Atlantic salmon)	E	407
Erosion of scales	*Catostomus commersonni* (white sucker)	E	328
Erosion of dorsal muscles	*Morone chrysops* X *M. saxatilis* hybrids	E	611
	Barbus barbus (barbel)	E	775
Hypoactivity	*Salmo gairdneri* (rainbow trout)	E	618, 1112
Lower feeding rate	*Micropterus salmoides* (largemouth bass)	E	475
Increase of oxygen consumption	*Salmo gairdneri* (rainbow trout)	E	325
Increase of drag	*Anguilla anguilla* (European eel)	E	984
Balance modifications	*Salmo salar* (Atlantic salmon)	E	555
Restriction of dorsal fin movements	*Cyprinus carpio* (carp)	E	564
Irregular swimming	*Salmo gairdneri* (rainbow trout)	E	375
Rupture of incision zone	*Micropterus dolomieui* (smallmouth bass)	S	1080
	Micropterus punctatus (spotted bass)	S	1080
	Micropterus treculi (Guadalupe bass)	S	1073
	Stizostedion vitreum canadense (sauger)	S	1032
	Lepomis macrochirus (bluegill)	S	453
Transmitter encapsulation by peritoneum	*Salmo gairdneiri* (rainbow trout)	S	330
Transintestinal expulsion	*Ictalurus punctatus* (channel catfish)	S	356, 533
	Salmo gairdneiri (rainbow trout)	S	130
Fungal infection	*Salmo salar* (Atlantic salmon)	G	951
	Morone americana (white perch)	S, E	375
Irritation by permanent suture material	*Barbus barbus* (barbel)	S	775
Necrosis of pelvic girdle	*Lepomis macrochirus* (bluegill)	S	453
Rectal erosion	*Ctenopharyngodon idella* (grass carp)	S	482
Alteration of gonads	*Salmo gairdneri* (rainbow trout)	S	647
Internal hemorrhages	*Ambloplites rupestris* (rock bass)	S	660
Weight loss in the long run	*Micropterus salmoides* (largemouth bass)	S	380, 681
Erratic behaviour	*Micropterus salmoides* (largemouth bass)	S	380
Reduction of social tendencies	*Micropterus treculi* (Guadalupe bass)	S	1073

Since it is almost impossible to assess directly in the field for the effect of transmitter or handling on animal behaviour, many authors laid the stress on the need for preliminary feasibility studies on transmitter attachment, always keeping in mind that specific new problems may arise when tagging a "new" species. References of the most relevant or complete feasibility studies conducted since 1957 are listed below.

Attachment feasibility studies : 32, 85, 99, 130, 141, 170, 171, 177, 181, 251, 253, 271, 325, 330, 356, 363, 375, 401, 416, 461, 475, 533, 539, 572, 582, 588, 591, 609, 617, 618, 619, 635, 641, 660, 727, 741, 742, 758, 766, 775, 836, 877, 878, 933, 945, 951, 1032, 1039, 1060, 1073, 1074, 1075, 1112.

Since advances in battery technology allow to produce transmitters with much longer life than in the early years of telemetry, long term tracking studies (over years) tend to spread more and more. From this point of view, surgical implantation procedures which appear to be the most reliable in the long run tend to emerge as the best solution in present and future telemetry. The most currently used and performant techniques are described in the papers with the corresponding reference numbers.

Surgical attachment : 137, 208, 236, 397, 427, 452, 472, 482, 532, 537, 604, 647, 706, 715, 827, 997, 1112.

DATA COLLECTION AND ANALYSES.

Besides the advances in transmitting or decoding technologies, considerable developments in other scientific fields helped considerably in long-range detection as well as in the automation of data collection and processing. The papers concerned with these aspects of telemetry are listed in the three following rubriques.

Computer and automation : 75, 135, 216, 421, 432, 469, 471, 490, 552, 665, 691, 696, 697, 704, 767, 768, 721, 794, 795, 847, 851, 854, 859, 886, 891, 899, 900, 906, 907, 930, 952, 956, 957, 1023, 1024, 1040, 1052, 1114.

Satellite : 24, 155, 156, 242, 256, 259, 260, 293, 316, 357, 400, 446, 509, 529, 538, 552, 557, 558, 687, 725, 740, 767, 769, 803, 845, 879, 887, 910, 915, 953, 968, 980, 1059.

Data analyses : 22, 44, 59, 154, 169, 188, 369, 402, 650, 674, 675, 696, 697, 714, 986, 987, 1026.